LEARNING 3 EXPERIENCE

Agents of Disease

PROLOGUE Long before microbes were identified as the causative agents of infectious disease, humans pondered the origins of disease and of the devastating epidemics that often decimated human populations. In trying to find a reason for this suffering, different cultures developed various explanations for disease: unknown poisons, bad air, evil spirits, divine retribution. Disease was often viewed as divine punishment for sins or aberrant behavior, and afflicted individuals were tortured or even executed.

Even without any knowledge of microorganisms, careful observation of patterns of disease led groups of people to understand that certain diseases were *communicable* (spread by contact with other humans or animals and through food and water), and that they could be prevented by good hygiene and careful food preparation practices. But, what exactly was being communicated and causing disease?

In this learning experience, you will explore the agents that cause disease. Using your prior knowledge about the spread of disease and adding new information about the causative agents, you will determine what is causing sickness and death among young adults in New Mexico. Like epidemiologists, you will examine data, apply your understanding, and finally determine if there is a way to prevent the transmission of the disease.

READING

Bacteria and Viruses and Parasites, Oh My!

Research in the late 1800s by a number of scientists provided evidence that many diseases were caused by microorganisms. The first conclusive demonstration that bacteria could cause disease was described in the work of Louis Pasteur and Robert Koch. Working independently, each scientist demonstrated that anthrax, a serious disease in domestic animals which is also transmissible to man, was caused by bacteria found in the bloodstream. The work of Pasteur, Koch, and other scientists in the field ushered in an era of discovery in which bacteria, viruses, and parasites were shown to be the causes of infectious diseases around the world.

In 1876, Koch proposed a set of criteria by which a microorganism could be determined to be an infectious agent (or *pathogen*). These criteria included:

- The microorganism must be present when the disease is present but absent in healthy organisms.
- It must be possible to isolate the microorganism.
- The isolated microorganism must cause disease when placed into a healthy organism.
- It must be possible to reisolate the microorganism from the second diseased host.

These criteria, called *Koch's Postulates*, are still used today to determine whether a disease is caused by an infectious agent. All organisms live in some kind of environment that provides them with nutrients and shelter in which to grow and replicate. In some cases, an infectious agent can survive in a number of different environments such as soil, water, a plant, or an animal, and it is only a matter of chance where the agent finally appears. In other cases, an infectious agent, for one reason or another, can live only within another organism, the host. Often the reason for this is that these pathogens require the nutrients that the host organism provides. The host becomes the environment from which the infectious agent derives everything it needs to survive. These organisms can only survive in one specific environment, which may be a plant or an animal or a bacterium. In some cases, the specificity may even extend to the type of tissue or cell in which the pathogen must live.

Wherever it lives, an infectious agent must grow and replicate. In order to do this, it must locate a suitable environment, take up nutrients, and release byproducts of its own metabolism. In carrying out these processes of life, the organism may deplete the nutrients in the environ-

ment, release toxic substances, and cause physical damage to its surroundings. The depletion of nutrients, damage from toxic substances, and mechanical damage can all contribute to causing the symptoms characteristic of the host's disease associated with that infectious agent. There are three major types of *pathogenic* (disease-causing) agents: bacteria, viruses, and parasites. Although fungi are also important in some diseases, they will not be considered here.

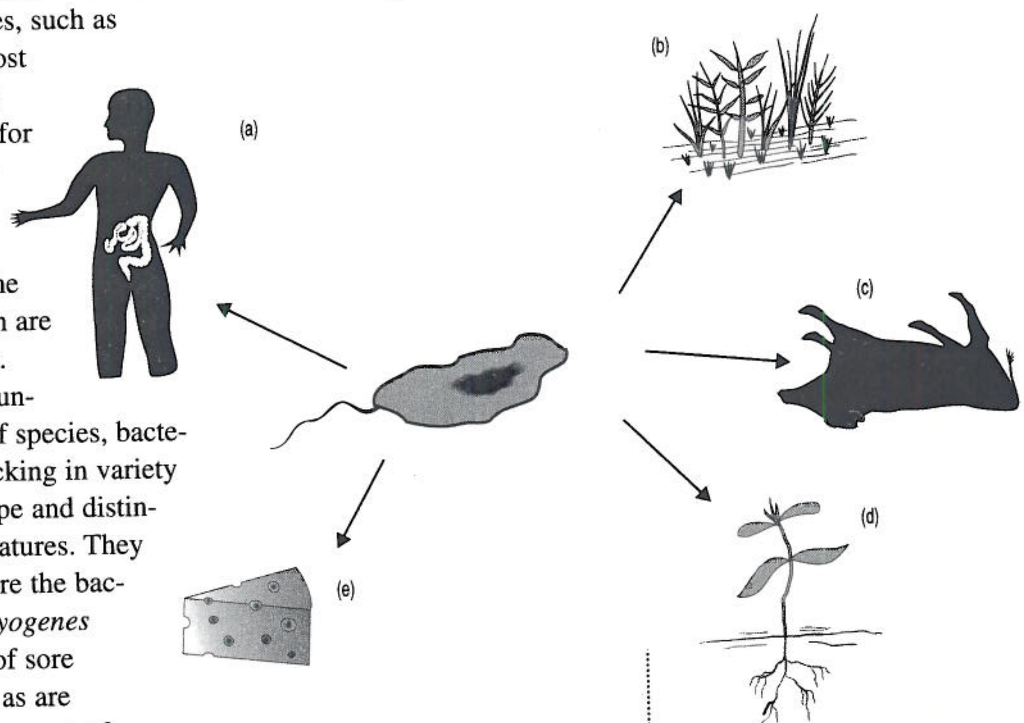
THE OLDEST ORGANISMS

For the first two billion years of Earth's existence, bacteria were its only tenants. Structurally the simplest of life forms, bacteria are single-celled prokaryotic organisms. Although capable of carrying out all of the cellular life functions, bacteria lack the internal structures, such as a nucleus and mitochondria, that are found in eukaryotic cells. Bacteria are also characterized by a cell wall, made up of polysaccharides, surrounding the cell membrane.

Bacteria constitute a large and diversified group of organisms. Capable of growing in a remarkably wide range of habitats and conditions, bacteria can be found just about anywhere—in the saltiest sea, in the hottest hot spring, and in the most acid or alkaline conditions. They make the soil fertile: in every gram of fertile soil there exist about 100,000,000 living bacteria; this amounts to about 90–250 kg (200–550 lb) of bacteria for every acre of soil. Bacteria decompose dead organic matter, help plants obtain vital nitrogen from the air, help us make vitamins and fend off undesirable microbes, and provide us with some of life's pleasures, such as yogurt and cheese. Most mammals are walking apartment complexes for a wide variety of bacteria, some of which are essential to the well-being of the animal, most of which are just along for the ride.

Despite their abundance and diversity of species, bacteria are remarkably lacking in variety when it comes to shape and distinguishing structural features. They can be spherical, as are the bacteria *Streptococcus pyogenes* (the causative agent of sore throats); rod-shaped, as are *Salmonella typhi* (the cause of

Figure 3.1
Bacteria carry out many roles in life: (a) helping animals make vitamins; (b) keeping the soil fertile; (c) decomposing dead matter; (d) fixing nitrogen into nitrates; (e) carrying out processes that result in cheese.



typhoid fever), *Vibrio cholerae* (the causative agent of cholera), and *Pseudomonas aeruginosa* (bacteria commonly found in soil); or they can be helical or spiral-shaped, as are *Treponema pallidum* (the cause of syphilis) and *Spirochaeta picatilis* (large and harmless spirochete common in water).

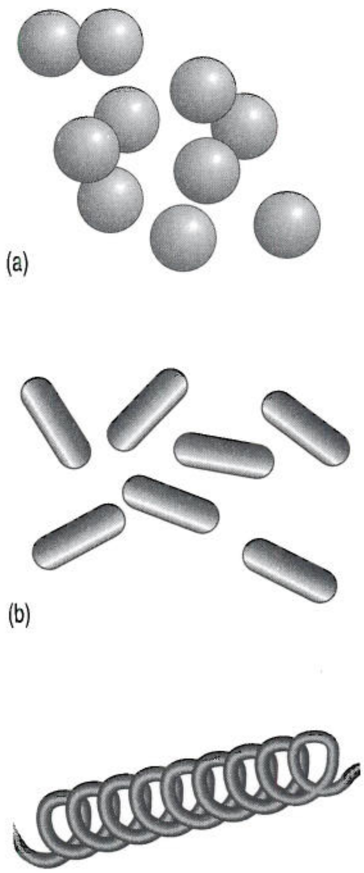


Figure 3.2
Three shapes of bacteria: (a) spherical; (b) rod-shaped; (c) helical.

Because bacteria have limited mobility, they must rely on carriers such as animals, water, or food. Insect bites and fecal material from birds, rodents, cats and other animals can also transmit bacteria. Though most people are scarcely aware of the bacteria around them, life would be very difficult—if not impossible—without bacteria. Despite all the important things bacteria provide, people generally only recognize the existence of bacteria when they become ill. For this reason, bacteria are generally viewed as "bad." Like all living things, however, bacteria are only carrying out the processes of life, which include taking nutrients from their environment so that they can grow and reproduce. For the majority of bacteria, this environment is the soil or water, but for others, this environment is another organism. That organism may become diseased as a result.

The troublesome, pathogenic bacteria are only a small portion of the total bacterial world. Lewis Thomas in "On Disease" put it this way:

> *It is true, of course, that germs are all around us; they comprise a fair proportion of the sheer bulk of the soil, and they abound in the air. But it is certainly not true that they are our natural enemies. Indeed, it comes as a surprise to realize that such a tiny minority of the bacterial populations of the earth has any interest at all in us. . . It is probably true that symbiotic relationships between bacteria and their . . . hosts are much more common in nature than infectious disease. . . . But if you count up all the indispensable microbes that live in various intestinal tracts, supplying essential nutrients or providing enzymes for the breakdown of otherwise indigestible food, and add all the peculiar bacterial aggregates that live like necessary organs in the tissues of many insects, plus all the bacterial symbionts engaged in nitrogen fixation in collaboration with legumes, the total mass of symbiotic life is overwhelming. Alongside, the list of important bacterial infections of human beings is short indeed.*
>
> *Excerpted from "On Disease," copyright (c) 1979 by Lewis Thomas, from* The Medusa and the Snail *by Lewis Thomas. used by permission of Viking Penguin, a division of Penguin Books USA, Inc.*

When bacteria do cause disease they can do it in a variety of ways. Living in blood, on skin, on mucous membranes, and sometimes within

cells, these tiny invaders may secrete toxic substances that damage vital tissues, feast on nutrients intended for the cell, or may form colonies that disrupt normal functions in the host's body. Directly or indirectly, their actions can cause extensive damage to the host.

The presence of bacterial cell walls makes some bacteria susceptible to treatment with antibiotics. *Antibiotics* are chemical compounds that either kill or inhibit the growth of bacteria. Certain antibiotics act by interfering with the synthesis of the cell wall. Because animal cells do not have a cell wall, antibiotics affect only the infecting bacteria. When first discovered in the 1920s, antibiotics were viewed as miracle drugs capable of saving humankind from the devastating diseases that had plagued them throughout history. However, almost as soon as a new antibiotic was discovered, certain bacteria with the ability to resist its killing effect were found. These were able to survive and multiply while the more susceptible bacteria were killed. Bacterial resistance to antibiotics is now one of the biggest challenges facing medical practitioners today.

THE VIRAL INVADER

Viruses have an enormous impact on human beings and, like bacteria, have been part of our lives since at least the beginning of recorded time. A *bas relief* from 1500 B.C. Egypt depicts a priest with a shriveled leg, evidence of infection with polio virus. A thirteenth-century manuscript shows a dog, mouth foaming, attacking a terrified man destined to die from the rabies virus transmitted from a dog bite. Smallpox is believed to have helped a small band of Spaniards under Cortés subdue the vast and powerful Aztec nation.

These microbes, too small to be visible even under the light microscope, were discovered not long after bacteria were implicated as the causative agent in anthrax. Their existence was demonstrated in 1892 by the Russian scientist Dimitri Ivanovsky, who was investigating the cause of a disease in tobacco plants.

As perpetrators of disease, viruses have been viewed as one of the "bad guys" of the microbial world. Variously termed "pirates of the cell", "viral hitchhikers", "cellular hijackers", and "pieces of bad news wrapped up in protein", these tiny microbes have been perceived as having evil intent. In reality, viruses are just simple microbes, genetic material (that is, nucleic acid) surrounded by protein. A virus is not a cell. It cannot maintain the characteristics of life on its own. Lacking the biochemical and structural components (cellular machinery) that enable an organism to carry out the life processes—no membrane, no nucleus, no mitochondria and thus no capacity to take up and utilize nutrients—it cannot reproduce, metabolize, or conduct any of the basic processes of life. A virus must seek out an environment that provides not only the nutrients it needs to carry out life processes but also the cellular machinery required for these processes—that is, a cell. A virus cannot

live outside a cell. Viruses exist for almost every kind of cell: bacterial, plant, fungal, and animal.

Much smaller than any cell, a typical virus is comprised of a protein "coat" surrounding its viral genetic material (see Figure 3.3). This genetic material contains specific instructions for making identical copies of the virus. The proteins encoded by the viral genes must be able to take over the cellular machinery of the cell; this "commandeered machinery" is then used to aid the reproduction of the virus and, in many cases, is no longer available for the growth and reproduction of the invaded cell. A virus enters the cell and, using different mechanisms depending on the kind of virus it is, causes the cell to stop making what it needs for itself and instead makes what the virus needs to reproduce. Like an unwanted guest who eats everything in the refrigerator, uses every clean towel in the house, and on leaving reduces your house to a pile of rubble, the virus utilizes the building blocks and energy stored that the cell has generated for its own growth and reproduction. The cell is depleted of the materials and energy it needs to repair the damage. The machinery the cell needs to make more of itself is no longer under its control. As a result, the cell often dies from this invasion.

Having no cell walls, viruses are not susceptible to antibiotics. Unlike the discovery of antibiotics for treating bacteria, no "miracle" drugs have been discovered for the treatment of viruses. In fact, to date, no truly effective *viricidal* (virus killing) drugs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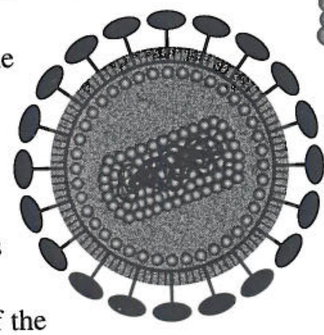
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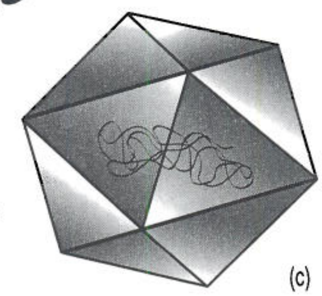
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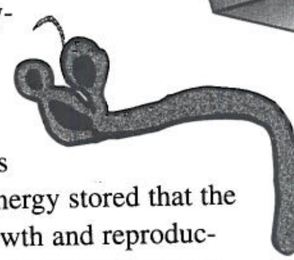
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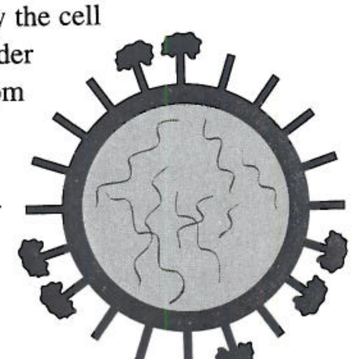
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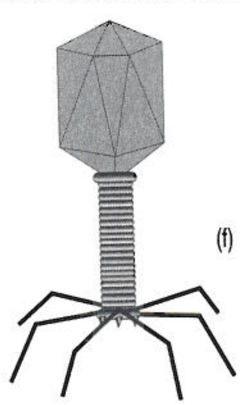
(f)

Figure 3.3
Various kinds of viruses: (a) tobacco mosaic virus; (b) human immunodeficiency virus (HIV); (c) polio virus; (d) Ebola virus; (e) influenza virus; (f) bacteriophage T4.

exist. In most instances, treatment of viral infections involves prevention (vaccines) or in helping the body to help itself, which means sleeping, drinking plenty of fluids, and eating chicken soup.

THE PARASITIC WAY OF LIFE

The parasitic way of life is highly successful. There are far more kinds of parasitic than nonparasitic organisms in the world. Those organisms which are not parasites are usually hosts. Even parasites are often hosts for other parasites. Or, in the words of Jonathan Swift:

Big fleas have little fleas
upon their backs to bite 'em,
Little fleas have lesser fleas and so, ad infinitum

The parasitic way of life is one form of living relationship called *symbiosis*. A symbiotic relationship involves any two organisms that live together in close association, often with mutually beneficial results and sometimes not. When a symbiont actually lives at the expense of the host, that is, uses nutrients required by the host, then it is called a *parasite*. Some parasites live their entire mature lives within or on the host, but others, such as fleas or mosquitoes, only visit for a meal—they eat and run (or fly). Parasites can be unicellular protozoa, such as the plasmodia that live inside red blood cells and are the causative agent of malaria, the major infectious disease in the world today; worms such as tapeworms, which live in the digestive tract; schistosomes that inhabit the veins of the bladder or intestines and are the causative agents of schistosomiasis; or arthropods, such as fleas and ticks, temporary parasites that visit the host for frequent or occasional feedings. There are also parasitic fungi, including mushrooms, molds, and mildews which feed on plants or animals. By this definition, certain bacteria and viruses can be considered to live as parasites. In the conventional definition, the term parasite refers only to eukaryotic organisms.

A parasite is often associated with damage to the host. A parasite may harm its host in any of a number of ways: by mechanical injury, such as boring a hole in it; by eating or digesting and absorbing its tissues; by poisoning the host with toxic metabolic products; or simply by robbing the host of nutrients. Most parasites inflict a combination of these conditions on their hosts. Of

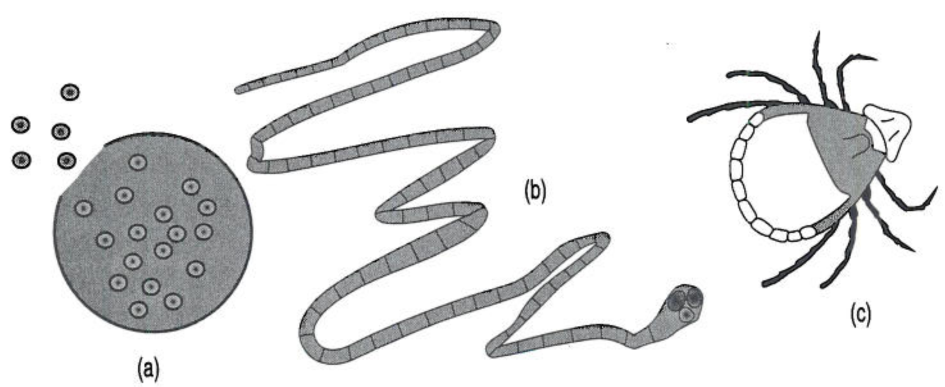

Figure 3.4
Various kinds of parasites: (a) plasmodia, microscopic parasites in a red blood cell; (b) tapeworm, a flatworm that can grow to more than 10 M in length; (c) tick, an insect the size of a pinhead. (Pictures not drawn to scale.)

course, the parasite is only trying to survive, taking from its environment what it needs to sustain its life processes so that it can reproduce. Parasites do not have evil intent, any more than bacteria or viruses do.

The treatment of parasitic diseases reflects the great diversity of parasites. Many unicellular parasites can be treated with drugs such as quinine for malaria and arsenic derivatives for sleeping sickness. Tapeworms and nematodes can also be treated with drugs which interfere with their metabolism. Although no vaccines exist to date, many parasitic diseases can be prevented by good hygiene, sanitary facilities, and effective programs of insect control. A simple change of habits, such as staying out of lakes and rivers, could prevent many serious, debilitating diseases. Parasites can be transmitted in a variety of ways: in contaminated food or water, by direct contact, or in the feces or saliva of an insect or other animal.

THE HOST-INFECTIOUS AGENT INTERACTION

Despite their great diversity in structure and habits, all infectious agents have the same life requirements for survival: to grow and to reproduce themselves. These requirements, in fact, are shared with all living things. To fulfill these needs all living things must obtain nutrients and live at appropriate temperatures and levels of moisture, pH and oxygen. Organisms derive these essential components from their environment, which in the case of infectious agents, happens to be another living organism.

In many instances, the organism in which the infectious agent has taken up residence is not always a gracious host. Many host organisms have evolved ways to try to rid themselves of unwanted houseguests. Animals, plants, and even bacteria have developed a wide arsenal of physical, chemical, and biological strategies against invading organisms. In humans, the immune system has developed an elegant and complex response to infectious agents. Specific proteins called *antibodies* are made in response to almost every foreign substance that enters the body. (In fact, invading organisms can often be identified based on the kind of antibodies present in the body.) These antibodies bind to the foreign substance and mark it for destruction. If this substance is part of a virus, bacteria, or parasite, the organism may be doomed.

Antibodies are one kind of host response against infection; specialized cells are another. Certain cells of the immune system are mobilized and become an army of white blood cells that circulate through the body and destroy the invaders. The function of these white blood cells is to engulf and destroy pathogens, and to produce toxic substances designed to kill infected cells and invading organisms.

As with all living things, infectious organisms affect their environment as they grow. It does not benefit the infectious agent to harm its environment in the process of living, since the well-being of that envi-

ronment or host is essential to the infectious agent's own well-being. Many host–infectious agent relationships exist in a balance in which the two partners have evolved to tolerance; the agent takes from the host what it needs without damaging the host, and the host tolerates the presence of the agent by not defending itself too vigorously. Other host–infectious agent relationships have not reached this level of tolerance, and the result is disease.

ANALYSIS

1. How would you define an infectious disease? A noninfectious disease?
2. What is meant when an organism is termed an "infectious agent"?
3. Create a table that compares each type of infectious agent—bacterium, virus, and parasite—using the following criteria:
   - a. how the agent is spread
   - b. the symptoms this agent might cause
   - c. biological characteristics of this agent and the significance of its characteristics
   - d. methods of treatment
4. Why do some infectious agents make you sick?

ACTIVITY

THE CASE OF THE KILLER CONGESTION

INTRODUCTION

Long-distance runner Merrill Bahe was on his way to his girlfriend's funeral on May 14, 1993, when he found himself gasping for air. Suddenly, and quite dramatically, Bahe was overcome with fever, headache, and respiratory distress. In the presence of his grief-stricken relatives, Bahe gulped desperately for air in their car, en route south to Gallup, New Mexico.

Minutes later the nineteen-year-old Navajo athlete was dead.

His twenty-four-year old girlfriend had died in a small Indian Health Service clinic located sixty miles away from Gallup a few days earlier after an identical bout of sudden respiratory illness. And within the week her brother and his girl-

friend, also young, athletic Navajos, who lived in trailers near Bahe's, fell mysteriously ill; the young woman died.

Excerpt from The Coming Plague *by Laurie Garrett, copyright 1994. Reprinted by permission of Farrar, Straus and Giroux, Inc., page 528.*

Chilled by the sudden deaths of these apparently healthy, young adults, attending physician Bruce Tempest put out a call to other physicians and colleagues in the state, describing the symptoms and requesting immediate notification if other cases were seen. By the end of the day he had compiled a list of five more healthy young people who had died of acute respiratory distress syndrome. Within the week the list grew to nineteen suspected cases, twelve of whom had died.

The disease seemed to follow the same pattern in every victim. It started with flu-like symptoms of fever, muscle aches, and headaches. After a period of a few hours to two days, those symptoms worsened to coughing and irritation in the lungs which seemed to be caused by leaks in the capillary network feeding the lungs with blood. This leakage of the plasma fluid from the blood filled the air sacs of the lungs. Shortly thereafter, the patients were unable to absorb oxygen from the air they took into their lungs. Starving for oxygen, the heart would slow down and death could soon follow.

TASK

As a modern epidemiologist would, you must determine what is causing the killer respiratory distress syndrome, how it is being transmitted, and then determine if anything can be done to stop the epidemic. Like teams of epidemiologists from the Centers for Disease Control and Prevention (CDC), your group will familiarize yourselves with information about the characteristics of a wide range of diseases and with the data about the specific epidemic.

When researching epidemics, time is always of the essence. The disease continues to spread. The longer you take to solve the problem the more deaths occur. You will have more than enough information so you must think carefully about the data, identify which data gives you information that will help you determine the causative agent, and determine which data is still inconclusive.

Each team will need to complete a report that records the decisions and information that led you to the identification of the causative agent and outlines your solutions to stopping the epidemic. For your report, you will need to do the following:

- Read the epidemiological, medical, and laboratory reports that follow.
- Examine Table 3.5, "Causes of Respiratory Distress," which contains information about various causes of respiratory distress and hemorrhagic (bleeding) symptoms and their characteristics.
- Use each report and your table to eliminate candidates.
- Record your rationale for each decision. For example, record how you decided whether the disease was infectious or noninfectious.
- Use the table you created from the Analysis of "Bacteria and Viruses and Parasites, Oh My!" to ensure that you have a complete picture.
- Write a report that contains the following information:
  - The nature of the epidemic; is it an infectious or noninfectious disease?
  - The probable causative agent of the epidemic, if infectious.
  - The process by which you came to the decision about the causative agent.
  - Diagnostic procedures to use on a new patient demonstrating symptoms of the disease.
  - Potential treatment for the disease.
  - The rationale for each decision.
  - Recommendations for preventing further spread of the disease.
- Be prepared to present the results of the data and your recommendations for stopping the epidemic to your fellow epidemiological teams.

REPORT ONE: EPIDEMIOLOGICAL DATA

1. Data about infected individuals (victims)

   Geographical distribution—lived in New Mexico and other parts of the Southwest, South, and Northwest United States

   Habits—worked in a variety of jobs; some held positions in maintenance or cleaning; no unusual hobbies

   Living Conditions—lived in trailers, small homes; generally in rural areas

   Relationships—in some cases victims were related; one instance of engaged couple as victims; primarily isolated cases of unrelated, uninvolved individuals

   Travel—no pattern of foreign travel or association with anyone who has traveled

2. Data about environment

   Recent rains and good growing conditions for seeds, nuts, berries, and insects had resulted in increase in rodent population.

REPORT TWO: MEDICAL DATA

1. *Symptoms*—respiratory distress, flu-like symptoms, fever, muscle aches, coughing, difficulty in obtaining oxygen
2. *Victims*—range of ages; many young adults
3. *Treatment*—antibiotics ineffective; no response to anti-protozoal drugs (drugs which eliminate parasitic, single-celled organisms or protozoans)
4. *Autopsy report*:
   - death by suffocation
   - rapid occurrence of death after onset of symptoms
   - air sacs in lungs filled with fluid, presumably from blood plasma leaking from pulmonary (lung) veins

REPORT THREE: LABORATORY DATA

1. *Mass spectral analysis*—negative for chemical toxins and heavy metals
2. *Examination of lung tissue and blood smears by direct stain and light microscopic analysis*—negative for visible pathogens
3. *Growth in culture from blood and lung tissue*—no growth demonstrated
4. *Immunology Report*:
   - large increase in number of white blood cells
   - results of antibody detection assays:
     - negative for *Toxoplasma gondii*, *Streptococcus pneumoniae*, *Mycoplasma*, influenza virus
     - inconclusive for Ebola virus, hantavirus, pneumocystis, Legionella, *Pasteurella pestis*

Table 3.5

Causes of Respiratory Distress	Type of Agent	Mode of Transmission	Geographic Location	Symptoms	Main Target Population	Treatment	Nature of Immune Response	Location in Body	Method of Detection	Prognosis
phosgene	chemical toxin; poison gas	aerosol as gas	worldwide	coughing; fluid filled lungs	all ages	NA*	NA*	blood; lungs; other tissues	mass spectral analysis**	damage to lungs
paraquat	chemical toxin; herbicide	ingestion of treated plants	South America; Central America	cough; congestion; fluid filled lungs	all ages	NA*	NA*	blood; lungs; renal and skeletal tissue	mass spectral analysis**	damage to lungs
influenza	virus	airborne; human to human	worldwide	fever; cough; muscle pain	all ages	bedrest; fluids	white blood cells; antibodies	inside a cell; lungs	antibody detection***	death in elderly and sickly; otherwise recovery
Ebola	virus	direct contact; human to human	Africa	internal bleeding; fluid loss	all ages	bedrest; fluids	white blood cells; antibodies	inside a cell; blood vessels	antibody detection***	80% death rate
hantavirus	virus	airborne; aerosol of mice feces	Asia; U.S.	congestion; fever; fluid filled lungs	all ages; especially adults between 20 and 60	bedrest; fluids	white blood cells; antibodies	inside a cell; blood vessels in lungs	antibody detection***	70% death rate
plague	bacteria (*Pasteurella pestis*)	fleas living on rodents	worldwide	fever; swollen lymphs; cough; pain	all ages	antibiotics	antibodies	lungs; blood; lymph glands	direct stain of blood smears; antibody detection***; culture****	generally fatal if untreated
Legionnaires' disease	bacteria (*Legionella*)	aerosol; "scum water" from appliances	U.S.	fever; muscle aches; congestion	all ages; older adults	antibiotics (often resistant)	antibodies	lungs; blood	direct stain of blood smears; antibody detection***; difficult to culture****	can be fatal if untreated

Continued on next page

Causes of Respiratory Distress	Type of Agent	Mode of Transmission	Geographic Location	Symptoms	Main Target Population	Treatment	Nature of Immune Response	Location in Body	Method of Detection	Prognosis
Mycoplasma pneumonia	bacteria	airborne; human to human	worldwide	persistent cough; fever; congestion	all ages	antibiotics	white blood cells; antibodies	inside a cell; lungs	antibody detection***; difficult to culture****	generally complete recovery
bacterial pneumonia (*Streptococcus* pneumonia)	bacteria	airborne; human to human	worldwide	cough; fever; ear ache	children	antibiotics (often resistant)	antibodies	connective tissue; lungs; ear canals	antibody detection***; culture****	generally complete recovery; may persist
Toxoplasma	parasitic protozoan	cat feces; undercooked meat	worldwide	congestion; convulsion paralysis; heart disease	newborns; generally asymptomatic in adults	anti-protozoal drugs	white blood cells; antibodies	inside a cell; lungs	antibody detection***	eventual recovery; may cause birth defects
Pneumocystic pneumonia	parasitic protozoan	believed to be airborne; human to human	Europe; U.S.	high fever in adults; air sacs filled with foam	malnourished children; weakened adults	anti-protozoal drugs	white blood cells; antibodies	inside a cell; lungs	direct stain of sputum; antibody detection***	often fatal

Notes for Table:

* NA means that the information is not available.

** mass spectral analysis is an assay for detecting chemical substances and heavy metals in blood and tissue.

*** Antibody detection is an assay in which the blood of victims is mixed with purified infectious agents. If antibodies specific to those organisms are present in the blood of victims, clumping will be seen in the sample, indicating that the antibody has bound to the added microorganism and that the person is most likely infected with that microorganism.

**** Culture is the growth of the organism on agar as you did in Learning Experience 2.

EXTENDING IDEAS

Long before the demonstration that microbes were responsible for disease and that these pathogens could be transmitted via water, food, air and animals, many cultures had established rituals, taboos, and customs which, in part, were developed to avoid illnesses observed to be associated with certain hygienic or food practices. The Navajo had long ago made a connection between mice and disease, as evidenced by the following excerpt from "Death at the Corners."

When a mysterious mouse-borne illness began claiming the lives of young Navajos last spring, tribal elders blamed the deaths on the tendency of young generations to drift away from traditional belief. The elders may have been right.

Contact with mice has always been prohibited in Navajo culture. While mice are revered because they brought life to the world by spreading seeds, they are also thought to have dangerous powers. They belong to the night world, whereas humans belong to the day world, and the two must remain apart. Mice must be kept out of houses and away from food, and if a mouse so much as touches your clothes, the garments must be burned...

From a medicine woman in Monument Valley, Muneta [a doctor from the Indian Health Service] learned that mice must never be touched or allowed in the home because they are "bearers of illness from ancient times." Their droppings and saliva are believed to cause disease. Anything a mouse touches might be contaminated, hence the requirement to burn clothing. The Navajo word for mouse, na'atoosi, *means "the one that sucks on things." The implication, says Muneta, is that it leaves behind its saliva . . .*

Muneta translated the mouse's power into the aerosolized viral particles [from the mouse droppings] that spread disease. She [the medicine woman] also told him that "the mouse would choose the strongest and best person in the house." Unlike other infectious ailments, hantaviral diseases tend to strike young healthy adults rather than small children and the elderly.

Excerpted from "The Mouse Injunction" from Death at the Corners by Denise Grady, Discover Magazine, *December 1993, pp. 83–91.*

Describe a tradition, ritual, or custom that you think is based on an understanding of infectious disease and its spread. Provide a possible explanation of what kind of infectious disease it might have been designed to prevent and how this custom might achieve this.

Parasitic diseases in developing countries are a great drain on the economic infrastructures of these countries. Research one disease caused by a parasite. Then describe the parasite's life cycle, the symptoms of the disease, and how this disease could cause financial loss in the country.

ON THE JOB

EPIDEMIOLOGIST Are you interested in solving problems, looking for clues or identifying patterns? Epidemiologists plan and conduct studies to examine trends in the incidence of disease and the public health impact of a specific disease. An environmental epidemiologist studies the incidence of disease in industrial areas and the effects of industrial chemicals on health. Epidemiologists plan and collect data such as areas in which disease is located, any relationships between victims, relevant medical data, known information about the cause of disease (viral, bacterial, genetic) and the mode of transmission. Next epidemiologists analyze data to identify possible causative agents and the mode of transmission to identify treatment and prevent further spreading of the disease. Epidemiologists may work in universities, for government organizations such as the Centers for Disease Control and Prevention (CDC) or for nonprofit organizations such as the American Cancer Society. Epidemiologists have a minimum four year college degree in biological or applied sciences and often a master's or doctorate from a school of public health. Classes such as biology, chemistry, epidemiology, mathematics, statistics, English,and computer science are recommended.